CHAPTER 2

SAFETY, HEALTH, AND FIRE FIGHTING SECTION

Section I. General Safety

GENERAL PETROLEUM SAFETY

Handling petroleum products presents many unique safety hazards. However, handling POL products correctly is very safe. This chapter gives POL receipt, storage, and issue safety procedures. Table 2-1, page 2-2, lists some general safety procedures. Explosions and fires caused by ignition of combustible mixtures of POL vapors and air causes some of the most serious POL-related accidents. Thus, controlling POL vapor formation and ignition sources at all times is critical. Table 2-2, page 2-3, and Table 2-3, page 2-4, give control methods. Table 2-4, page 2-5, gives safety precautions unique to POL transfer and storage.

SAFETY TRAINING

Safety training is the key to preventing accidents. Safety training must start during the soldier's initial entry training and it must continue throughout his military service. All fuel handlers should know about petroleum. They must also know the safety principles for handling and using petroleum products. In addition, they should know self-care techniques, fire prevention, and first aid and emergency safety procedures.

PETROLEUM FIRE AND EXPLOSION HAZARDS

The primary danger while handling petroleum is the chance of a fire or explosion. The paragraphs below describe petroleum properties affecting flammability and explosive characteristics. They also discuss issues and techniques related to reducing the chance of fire and explosion when storing and handling petroleum products. Here are some terms that you must know.

Flash Point

A fuel's flash point is the lowest temperature the fuel's vapor will catch fire momentarily (flash) when exposed to a flame. The lower a fuel's flash point, the more dangerous it is. Some sample flash points are: AVGAS, -50°F, JP-4, -10°F; and JP-8, 100°F. These flash points show that fuels give off ignitable vapors at temperatures normally found in Army units. Aviation-related fuels can ignite even in sub-zero temperatures.

Explosive Range

Petroleum vapor and air may form a range of mixtures that are flammable, and possibly explosive. This range is called the mixture's "flammability limit," "explosive range," or "explosive limit." A mixture in the explosive range ignites when it contacts a spark, flame, or other ignition source. In open spaces, this causes an intense fire. In enclosed spaces (such as an empty tanker), the mixture explodes. Gasoline's explosive range, for example, is from 1 to 8 percent by volume of gasoline vapor per given air volume. Any mixture above 8 percent by volume of gasoline vapor does not ignite because it is too "rich." For example, there is not enough oxygen present to burn the fuel. This is known as the mixture's upper explosive limit. A mixture less than 1 percent by volume of gasoline vapor does not ignite because it is too "lean." For example, there is not enough fuel in the air to burn. This is known as the mixture's lower explosive limit. A mixture's lower explosive limit is formed at about the product's flash point. Thus, AVGAS vapors can burn or explode at temperatures as low as -50°F. Explosive ranges vary among fuel types. They form over temperature ranges normally found by the military. The key point is an empty or nearly empty petroleum tank or container is still very dangerous due to remaining fuel vapors.

Table 2-1. Petroleum safety precautions.

RULES	REMARKS
No Smoking	Strictly enforce NO SMOKING rules.
No Smoking Signs	Post NO SMOKING WITHIN 50 FEET signs where they can be seen.
Fire Extinguishers	Place fire extinguishers and other fire fighting equipment within easy reach but where it will be safe from a fire.
Flame-and Spark-Producing Equipment	Do not use open flames, heating stoves, electrical tools, or other such apparatus in petroleum storage and work areas.
Explosion-Proof Equipment	Use only authorized tools, equipment, and clothing. Use explosion proof lights and flashlights.
Tools	Keep tools and equipment in safe and good working condition.
Equipment Bonding and Grounding	Bond and ground pumps, tank vehicles, and storage tanks.
Notched-Handle Nozzles	Ensure notched handles are only on nozzles with automatic shutoffs. Tend all nozzles constantly while they are being used in refueling operations. If you must use notched handles on nozzles that do not have automatic shutoffs, make sure the notches are modified so that the nozzles must be held open by hand.
Spills	Control spills with a proactive spill prevention program. Immediately clean up and report spills.
Leaks	Place drainage tubs or containers under hose connections, faucets, and similar equipment. Repair leaks at once. Replace defective hoses, gaskets, and faucets.
Inspections	Inspect equipment, safety devices, and work areas frequently to ensure safety and to correct hazards.
Ventilation	Make sure work and storage areas are well ventilated.
Fuel Vapors	Avoid exposure to fuel vapors for long periods.
Protective Clothing	Wear fuel-resistant or rubber gloves and protective clothing to keep fuel off the skin. Wear ear protection when working in high noise areas.
Work Area	Keep the work area free of loose tools, lumber, and other objects that may cause accidents.
First Aid Training	Train personnel to give first aid and artificial respiration.
Solvents	Use only authorized solvents for cleaning.
Flame and Spark Arrestors	Put flame and spark arrestors on all equipment in and near petroleum storage areas.
Nylon Clothing	Never wear nylon clothing when handling petroleum because high electrostatic charges build up in nylon fabric.

Table 2-2. Precautions for controlling vapor formation.

RULES	REMARKS
Avoid spills.	Fill container carefully (whether filling a 5-gallon can, tank vehicle, or storage tank) and avoid overflow.
Use drip pans, catch basins, or absorbent materials.	Place them where there may be drips or spills.
Inspect frequently for leaks.	Always inspect tank seams, joints, piping, valves, or pumps for leaks.
Clean up spills or leaks at once.	Treat the area as especially hazardous until vapors are gone. When vapors are gone, remove the spill.
Beware of flammable vapors in empty containers.	Be very careful around empty pipeline or storage tanks, drums, cans, or containers that have held a flammable product. They are potentially more dangerous than a filled container.
Inspect drums and containers before use.	Inspect drums and containers before using. Mark them with some sign of approval if they are fit for use.
Keep containers closed.	Close empty or full containers for flammable products.
Open drum bungs carefully.	Be very careful when opening drums filled with flammable products if the drums have been subjected to increased temperature or agitation since they were filled. This prevents the sudden release of pressure that can produce a vapor-air mixture that may include some product.
Beware of unventilated spaces.	Be careful around unventilated or confined spaces or pits.
Do not use gasoline for cleaning.	Do not use gasoline and carbon tetrachloride (because it is toxic) for cleaning. Use only authorized cleaning solvents
Consult with others when conducting ventilating and vapor-freeing operations.	Consult other area operations that could be sources of ignition

Table 2-3. Precautions for controlling ignition sources

RULES	REMARKS
No Smoking	Strictly enforce NO SMOKING rules. Post NO SMOKING WITHIN 50 FEET signs where they can be seen.
No Matches or Cigarette Lighters	Collect matches and cigarette lighters at the checkpoint before entering the facility.
No handling of Products During Electrical Storms.	Place fire extinguishers and other fire fighting equipment within easy reach but where it will be safe from a fire.
Disposal of Waste	Do not use open flames, heating stoves, electrical tools, or other such apparatus in petroleum storage and work areas.
Explosion-proof Equipment	Use only authorized tools, equipment, and clothing. Use explosion proof lights and flashlights.
Tools	Keep tools and equipment in safe and good working condition.
Equipment Bonding and Grounding	Bond and ground pumps, tank vehicles, and storage tanks.
Notched-Handle Nozzles	Ensure notched handles are only on nozzles with automatic shutoffs. Tend all nozzles constantly while they are being used in refueling operations. If you must use notched handles on nozzles that do not have automatic shutoffs, make sure the notches are modified so that the nozzles must be held open by hand.
Spills	Control spills with a proactive spill prevention program. Immediately clean up and report spills.
Leaks	Place drainage tubs or containers under hose connections, faucets, and similar equipment. Repair leaks at once. Replace defective hoses, gaskets, and faucets.
Inspections	Inspect equipment, safety devices, and work areas frequently to ensure safety and to correct hazards.
Ventilation	Make sure work and storage areas are well ventilated.
Fuel Vapors	Avoid exposure to fuel vapors for long periods.
Protective Clothing	Wear fuel-resistant or rubber gloves and protective clothing to keep fuel off the skin. Wear ear protection when working in high noise areas.
Work Area	Keep the work area free of loose tools, lumber, and other objects that may cause accidents.
First Aid Training	Train personnel to give first aid and artificial respiration.
Solvents	Use only authorized solvents for cleaning.
Flame and Spark Arrestors	Put flame and spark arrestors on all equipment in and near petroleum storage areas.
Nylon Clothing	Never wear nylon clothing when handling petroleum because high electrostatic charges build up in nylon fabric.

Table 2-4. Precautions for transferring and storing petroleum products.

RULES	REMARKS
Bond and ground equipment	For all petroleum operations, always bond and ground equipment.
Avoid overhead filling.	If you cannot avoid overhead filling, put the filling line inside the tank so that the fuel will be disturbed as little as possible.
Use walkways.	Always use walkways to cross tank fire walls. Always use walkways as much as possible.
Ventilate and clean vehicles and containers.	Collapsible tanks, railway tank cars, and tank vehicles must be cleaned and ventilated as prescribed in this FM.
Observe safety rules when refueling aircraft.	Observe all safety precautions described in this chapter.
Observe safety rules when operating, loading, and transferring products.	Observe all safety precautions described in this chapter.

Vapor Pressure

Vapor pressure is a measure of a fuel's tendency to form vapors (known as its volatility). Laboratory technicians normally use the Reid method to determine a liquid's vapor pressure. They determine vapor pressures at 100°F for comparison purposes. Knowing a liquid's vapor pressure has little practical application for petroleum handlers. However, petroleum products' relatively high vapor pressures (and in particular, gasoline and aviation fuels high vapor pressures) further show how easily fuels form explosive vapor mixtures in normal temperatures.

Distillation Range

Petroleum products are a mixture of hundreds of different chemical compounds. They boil (vaporize) over a relatively broad temperature range compared to pure substances. This temperature range is known as a product's distillation range. A product's distillation range is another relative volatility indicator. A product with a relatively low distillation range might vaporize in hoses or pumps, causing "vapor lock." Aviation fuels in particular have distillation ranges in the temperature ranges encountered during military operations.

Electrostatic Susceptibility

This is the relative degree a fuel will take on or build up a static electrical charge. Aviation peculiar fuels (JP-4 in particular) have relatively high electro static susceptibilities. This multiplies the danger of these highly volatile, flammable fuels.

Autoignition Temperature

This is the lowest temperature a fuel itself (as opposed to its vapor) will catch fire spontaneously. Some sample autoignition temperatures are: AVGAS, 825° to 960°F; JP-4, 470° to 480°F; JP-8, 440° to 475°F. Low autoignition temperatures present a particular hazard in aviation refueling operations. An idling turbine engine (such as a helicopter engine) produces an exhaust with a temperature between 440° to 475°F. Even after the engine is shut down, its temperature stays in this range for quite a time. If this engine temperature radiates to JP-4 or JP-8, the fuel could catch fire or explode. This could happen if a helicopter exhaust blows on a piece of refuel equipment or a fuel handler drags a hose across a hot engine.

SPECIFIC FUEL FIRE AND EXPLOSION HAZARDS

Fire and explosion hazards related to specific fuel types are given as follows.

Fuel Oil

Boiler fuels are not flammable at ordinary temperatures because of their high flash point. However, fuel oils heated above their flash points can easily ignite. They produce a hot fire that may be difficult to put out. Fuel oil also may have been mixed with lower flash point products that will increase its flammability.

Diesel Fuel

Diesel fuels will not ignite at normal storage temperatures unless they are contaminated with a more volatile product. They easily ignite if heated above their flash points. Once ignited, they produce a hot fire that may be hard to put out. These fuels spread quickly on both land and water and burn completely. An open flame or hot exhaust manifold can easily ignite a spray of diesel fuel from a leak or a sudden tank overflow.

Kerosene

Kerosene presents safety hazards similar to those of diesel fuel and fuel oil. Kerosene is not easy to ignite at normal operational temperatures. However, once it is ignited it will form a hot fire that is difficult to put out.

Gasoline

Gasoline, along with jet fuels, is a greater fire and explosion hazard than the fuels discussed above. Gasoline forms explosive mixtures above its surface, at gage openings or vents at temperatures above -70°F. Vapors from any size gasoline spill easily form explosive mixtures. Gasoline vapors, as all petroleum vapors, are heavier than air. This causes them to spread for long distances along the ground and collect in low places. Such vapors ignite easily. The resultant flash and explosion will travel back to the fuel source igniting it. Preventing small gasoline leaks is difficult. Therefore, there is always a danger of ignition from sparks and flames in gasoline storage and handling areas. Prevent gasoline vapor accumulation by proper storage facility ventilation and maintenance. Never allow gasoline to enter any drain line or sewer not designed to handle petroleum products.

Jet Fuels

Jet fuel flammability characteristics vary with fuel grade. However, follow the same safety precautions when handling all jet fuels. This is particularly important at large storage and handling sites where tanks and equipment handle several different fuel grades. JP-4 presents the most extreme safety hazard. JP-8 is replacing JP-4 as the Army's primary aviation fuel. However, JP-4 is still used in some areas. JP-4 is very dangerous because it forms explosive mixtures over all normal storage and operating temperatures. It also creates large quantities of static electricity when pumped and handled. Follow these precautions when storing and handling jet fuels:

- Use as small a storage tank as necessary to support the mission. When using hard wall storage tanks, avoid shallow tanks with large surface areas for jet fuel storage. If available, use floating roof storage tanks.

- Do not use overhead fill lines that permit product free-fall.

- Keep air out of fill lines.

- Use water bottoms in fixed tanks only when absolutely necessary. When using water bottoms, keep inlet connections above the water to reduce agitation. Water with entrained air rising through fuel creates a static electricity charge. Bubbles bursting on the fuel surface also create static electricity.

- When pumping fuel, you should pump at a reduced flow rate until the fuel submerges the tank inlet. Also reduce the pumping rate when the fuel level is near the tank top to reduce the risk of flashover to parts of the roof.

- Continually check bonding and grounding connections. Take special care to bond and ground gaging and sampling equipment properly.

FUEL PROPERTIES AND BEHAVIOR AFTER COMBUSTION

Other fuel properties determine behavior after ignition. They also determine fire and explosion control measures. These properties are given below.

Heat of Combustion

One relative measure of fire intensity or severity is the amount of heat produced as the fuel burns. Aviation peculiar fuels such as JP-4 and AVGAS have higher heats of combustion than multipurpose or motor fuels. Therefore, they produce more severe fires. In any case, all petroleum fires are intense. They require prompt action to quench the large amounts of heat they produce.

Flame Spread Rate

Aviation fuels containing gasoline (AVGAS) and gasoline and kerosene mixtures (JET B, JP-4) have flame spread rates of from 700 to 800 feet per minute. Kerosene-based fuels (JP-5, JP-8, Jet A-1, DF-2) have flame spread rates of approximately 100 feet per minute. Flame spread through a mist of any fuel type is nearly instantaneous.

Specific Gravity

Specific gravity is a relative measure of liquid density. Water's specific gravity is 1.0. All petroleum products have a specific gravity less than 1.0. For example, AVGASs specific gravity is .70 and JP-4's specific gravity is .78. This means they are lighter than water and will float on any water surface. Using water to put out a petroleum fire will cause it to spread as petroleum is carried along on the water stream flowing away from the fire. For this reason, use foams or dry chemicals, if possible, to put out petroleum fires.

Solubility

Fuels will not dissolve in water. This means water-based foams can be used for putting out petroleum fires.

FLAMMABLE AND COMBUSTIBLE PRODUCTS

Hazardous liquids (including petroleum products) are classified as flammable and combustible. In these broad categories, there are several class designations based on a liquid's volatility. Flammable liquids (Class I) have a flash point below 100°F (37.8 C) and a vapor pressure not above 40 PSI (absolute) at 100°F. Combustible liquids (Classes II and III) have a flash point at or above 100° F (37.8°C). Table 2-5 describes the various flammable and combustible liquids classes. Heated liquids are more volatile. Therefore, heated combustible liquids require the same safety precautions as flammable liquids.

Table 2-5. Flammable and combustible liquids.

CLASSIFICATION	FLASH POINT (°F)	BOILING POINT (°F)
Flammables:		
Class 1	Below 100	
Class 1A	Below 73	Below 100
Class 1B	Above 73	At or above 100
Class 1C	At or above 73 and below 100	
Combustibles:		
Class II	At or above 100 and below 140	
Class IIIA	At or above 140 and below 200	
Class IIIB	At or above 200	

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IGNITION SOURCES

Fires and explosions need an ignition source to start. Petroleum storage and handling sites require constant monitoring to detect and eliminate ignition sources. Some common ignition sources are as follows.

Smoking and Matches

Smoking and matches are the greatest single cause of fires. Units operating Class III supply points should prohibit any smoking-related materials in the supply point. Collect all smoking materials at the entrance checkpoint. Return these items at the exit checkpoint. Post NO SMOKING WITHIN 50 FEET signs at all petroleum handling, storage, and transfer areas.

Poor Housekeeping

Relatively small heat sources easily ignite trash, rags, scrap wood and other such items. Place such materials in closed metal containers. Dispose of them appropriately each day. Use only fire resistant wall lockers and cupboards for storage in petroleum supply areas. Never store newspapers or rags in them. Discard petroleum waste in an environmentally safe manner IAW local procedures. Label safety cans or other flammable liquid waste containers with a flash point below 100° F (37.8° C) (such as gasoline or JP-4) IAW 49CFR Part 172. Do not use waste cans larger than 10 gallons. Take steps to control grass and weeds in POL supply points.

Mechanical or Friction Sparks

Friction or impact between metals and other hard substances can cause sparks. These sparks can ignite flammable products and rubbish. Carefully control spark sources such as tools and grinding wheels around petroleum products and vapors. Nonsparking tools may cause sparks in certain uses. If available, use them; however, treat them as a potential source of sparks also.

Electrical equipment

Electrical equipment and wires create fire hazards when they produce exposed electrical currents (arcs and sparks) or when they create excessive amounts of heat. An arc is a continuous current stream through the air (similar to lightning). Operating knife switches and circuit breakers often produce arcs. The rotating parts of motors, generators, and similar machines produce arcs and sparks when operating. Overloaded electrical circuits produce hazards in two ways. One is by the large amounts of heat they produce. This heat may be enough to ignite a petroleum vapor mixture. The second is by arcing through worn or thin insulation. An oil-insulated switch or circuit breaker, designed to quench arcs from interrupted current, becomes a hazard when overloaded because the insulating oil vaporizes. Never put a penny or other conductive materials on the back of a blown plug fuse. A circuit overload can result. Likewise, never use fuses with a higher capacity than the circuit needs. Fixed and portable lights, generators, power tools, and extension cords present the same hazards. Use only explosion-proof electrical equipment where flammable vapors exist. This equipment should comply with Underwriters' Laboratory Incorporated standards. Also, all wiring and grounding must comply with the National Electric Code. Permit only licensed operators to operate generators. Allow absolutely no one to work on a vehicle's or aircraft's electrical system during refueling operations. This includes touching or moving batteries or using battery chargers. Allow vehicle or aircraft radios to be on to receive messages during refueling. However, do not allow radio transmissions due to the danger of arcing.

Static Electricity

Static electricity is an electrical charge built up in a material by friction with another electrically dissimilar material. You can create static electricity on yourself by rubbing your feet across a carpet. On a low humidity day, you can then dissipate the charge by touching something metal such as a doorknob or car door. This produces a spark and a shock to you as the charge dissipates. In the military, the flow of petroleum through hoses and pumps and into and out of metal tanks produce static electricity. Also, the flow of steam, air, and other gases through tank, pump and hose systems produces these charges. Aircraft or vehicles moving through the air or along roads produce static electrical buildup on them. This buildup cannot be predicted or prevented. However, it is not a danger until it builds into a charge that can spark. Petroleum handlers should assume the presence of static electricity during all petroleum transfer operations. They can prevent sparking by two methods: bonding and grounding (discussed below). Operators must properly bond and ground all equipment involved in a petroleum transfer operation before the start of the operation. Effective bonding and grounding must continue for the entire operation. Petroleum handlers should inspect ground wires and rods daily. They should repair any damage immediately. They should test the grounding system every five years. They should also test it after repairing damage. Static drag chains used on civilian vehicles to dissipate static electricity are not authorized on military vehicles.

Spontaneous Heating

Spontaneous heating of a combustible material takes place when its characteristics and the right environmental conditions cause a heat-producing chemical reaction. The heat can build to the point where the material ignites on its own. This is called spontaneous combustion. It may happen even if the material is not exposed to an external heat source. One common source of spontaneous heating is oil- or paint-soaked waste or rags, particularly those soaked with linseed oil and paint dryers. Petroleum handlers should consult MSDSs for the products they handle to see if they are subject to spontaneous heating and combustion, and if so, under what conditions. Many factors affect the start and speed of spontaneous heating and combustion. The process may take seconds or weeks with the same end result. Oxygen in the air or in oxygen-producing chemicals (oxidizers) accelerates the process. Here are several ways to help prevent spontaneous heating and combustion.

•Closely follow storage and safety instructions on all MSDSs.

•Keep storage and handling areas for petroleum and petroleum-based items properly ventilated.

•Do not use lockers or supply cupboards to store oily waste and rags. Instead, place them in airtight metal containers. Discard them as soon as possible IAW environmentally-safe local procedures.

Welding and Cutting

All welding methods present fire hazards. Welding-associated heat causes increased petroleum vaporization. Welding throws off molten metal globules that can ignite the vapors or liquid petroleum. Welding equipment's open flame can ignite vapors. Welding may not ignite vapors immediately; however, it can start smoldering fires in materials near the area. Eliminating these hazards completely is difficult or impossible. However, those involved in welding near petroleum products or equipment must closely control the welding process to prevent fires or explosions. Thoroughly clean and reduce vapors to acceptable safety levels in storage tanks, tank cars, tank vehicles, drums, and vehicle fuel tanks before cutting or welding them. Check local policies for doing such work. Usually you must get a permit from the local fire marshal before starting.

Radar

The beam of high frequency radar equipment can ignite a flammable vapor-air mixture. It can ignite the mixture by inducing heat in solid materials in the beam's path or by intensifying an existing electrical charge or stray current to the point where it will arc or discharge as a spark.

• Dangers. The degree of danger depends on the radar unit's peak power output. Some radar types are more dangerous than others.

• Safety measures. Take the following safety measures when handling fuel near these types of radar.

••Airborne weather-mapping radar. The crew of an aircraft with a weather-mapping radar unit must shut down the radar before and during aircraft refueling.

••Airborne surveillance radar. Airborne surveillance units must shut down before the aircraft approaches within 300 feet of a refueling or fuel storage area.

••Airfield surface-detection radar. Do not refuel an aircraft or store aviation fuel within 100 feet of the antenna of an airfield surface-detection radar.

••Airfield approach and traffic control radar. Do not refuel an aircraft or store aviation fuel within 300 feet of the antenna of an airfield approach and traffic control radar.

Open Flames

Any open flame will ignite fuel or a flammable vapor-air mixture. Do not allow any open flame, open-flame device, or lighted smoking materials within 50 feet of a refueling operation. Fuel handling personnel may not carry lighters or matches. Do not use exposed-flame heaters, welding or cutting torches, and flare pots within 50 feet of refueling operations.

STATIC ELECTRICITY CONTROL MEASURES

Static electricity is impossible to eliminate. However, there are several safety measures for controlling it and its effects. Petroleum handlers should always assume that static electricity is present during all phases of operations. This includes long-term storage. Sparking (and a subsequent fire and explosion) from static electricity is a real and ever-present danger in petroleum transfer operations. The two primary static electricity control methods are bonding and grounding.

Bonding

Bonding is connecting two electrically conductive objects to equalize electrical potential (static charges) on them. Bonding does not dissipate static electricity. It equalizes the charge on the two objects to stop the sparking in the presence of flammable vapors. This will most likely occur when a vehicle or aircraft is being refueled. In this case, a fuel handler should bond the refueling vehicle to the vehicle being fueled. Do this by touching the fuel nozzle to the vehicle before the nozzle dust cap or vehicle fuel tank cap is removed. Maintain the bond until the refuel operation is complete and the nozzle dust cap and vehicle fuel cap are replaced. This will reduce vapors in case a spark occurs when the nozzle touches. Bond all equipment being used in a petroleum handling operation.

Grounding

The earth, particularly soft damp earth, can accept electrical charges. The charges then dissipate harmlessly. To ground equipment, you must provide a conductive electrical path into the ground. This prevents a static charge from collecting on the surfaces of equipment where it could discharge as a spark. Fuel handlers form this path by connecting a conductive cable from the piece of equipment to a conductive metal rod driven into the earth to the level of permanent ground moisture. The connection to the equipment must be to a clean unpainted, nonoxidized metal surface. Frozen soil (a particular problem in arctic regions) makes it difficult to get a good ground. Fuel handlers may need to drive in grounding rods at several different locations to as great a depth as possible to ground a single piece of equipment. Another solution is to try to locate a grounding system near a heat source. If there are metal buildings or underground pipes nearby, a ground connection may be made to them. Rocky or sandy soils are poor grounds because they have low conductivity. Chemicals can be used to condition the soil and raise its conductivity. Magnesium sulfate (Epsom salts), copper sulfate (blue vitriol), calcium chloride, sodium chloride (common table salt), and potassium nitrate (saltpeter) are some of the chemicals used for soil conditioning. Table salt will probably be the easiest to get in the field. To use salt, prepare a grounding site by digging a hole about 1 foot deep and 3 feet across. Mix 5 pounds of salt with 5 gallons of water. Pour the mixture into the hole, and allow it to seep in. Install the ground rod and wire, and keep the soil around the rod moist. Ground rods are usually made of galvanized iron, galvanized steel, or copper-weld steel. The rod regularly used for grounding is LIN S08698, NSN 5975-00-224-5260. This ground rod is 3/4 inch in diameter and 6 feet long. It is made of galvanized steel. It has one pointed end that is driven into the earth and a bolt and nut at the other end for connecting a grounding cable. Use the following procedures to install, mark, test, and inspect ground rods.

- Install. Drive the rod into the earth to a sufficient depth to reach below the permanent ground moisture level. On a fixed airfield apron or ramp, drive the rod to a depth where its top is level with the surrounding surface. At other facilities, drive the rod to a depth where its top is low enough or high enough so people will not trip over it. If the rod’s top is level with the surrounding surface remove some soil from around the top to give room for attaching ground cable clips. Fuel handlers may use-tie-down bolts embedded in concrete ramps at fixed airfields as ground connections if they meet resistance requirements. Make ground connections to tiedown bolts on the eye of the bolt itself, not the tie-down ring.

- Mark. Encircle each rod installed in a hard surface permanently or semi permanently with an 18 inch diameter yellow circle, with a 2-inch (approximately 5 centimeters) black border surrounding it. These circles must be painted on. Stencil in black the words STATIC GROUND CONNECTION and a numeric or alphanumeric rod identification code in the circle's yellow portion. Local policies and conditions determine fixed rod numbering and spacing. No requirement exists to mark temporary ground rods this way.

• Test. Observe ground rods daily for damage. Test them after installation and every five years after or when obvious damage is discovered and after any damage repair. Appendix F gives detailed testing procedures

••Test requirements. An effective grounding system has a resistance of 10,000 ohms or less. The unit or agency that maintains fixed grounding systems must keep a log identifying each rod, the date tested, and the resistance reading. If a rod's measured resistance is greater than 10,000 ohms, immediately mark the rod DEFECTIVE-DO NOT USE and remove or replace it as soon as possible.

••Equipment. Test grounding systems with a multimeter. The most commonly used multimeter is TS-352B/U, LIN M81372, NSN 6625-00-553-0142.

GROUNDING AND BONDING TEST METHODS

No quick or easy way exists to test a ground's adequacy. The testing procedures in Appendix F are relatively complex. The required test equipment is bulky and expensive. For these reasons, several approved grounding and bonding methods and levels that meet the Army's various operational needs are given below.

Method 1

Equipment is grounded to a rod or rods with a measured resistance equal to or less than 10,000 ohms. These rod (or rods) ground both the refueling system or tanker and the vehicle or aircraft being refueled. In addition, the fuel handler bonds the refueling nozzle to the aircraft or vehicle he is refueling. Method 1 is the only acceptable grounding method, unless granted exceptions by appropriate authorities, at any fixed airfield or refueling point. It is the safest method.

Method 2

In some instances, equipment is not available to test resistance to ground. In such cases, fuel handlers can ground refueling equipment to untested grounding systems, subject to certain constraints. The unit commander authorizes this method when the location, tactical situation, or type of operation makes it impossible to test ground rods or to mark them in the manner appropriate for fixed rods. The grounding rod or rods are driven to a specific depth in the ground depending on the type of soil (see Table 2-6) at the site. The depth is determined by the normal depth of permanent ground moisture in the various soil types. The fuel handler grounds the refueler and the vehicle or aircraft being refueled are then grounded, and the nozzle is bonded to the aircraft. Use this method only when it is absolutely impossible to use the first method.

Table 2-6. Required depths for ground rods

Type of soil	Depth of ground rod
Coarse ground, cohesionless sands and gravels	6 feet
Inorganic clay, claying gravels, grave-sand-clay, claying sands, sandy clay, gravelly clay, and silty clay	4 feet
Silty gravel, gravel-sand-silt, silty sand, sand, silt, peat, muck, and swamp	3 feet

Method 3

In situations where the climate, terrain, or tactical condition make it impossible to secure a satisfactory ground rod, the authorizing commander may waive requirements to ground the aircraft or vehicle being refueled and fuel dispenser (system or refueler). The authorizing commander is the commander one level above the operating unit. However, he cannot waive the requirement to bond the fuel dispenser to the vehicle or aircraft under any circumstances. Method 3 relies on bonding alone. A bond is made between the aircraft and the refueling system or refueler and between the nozzle and the aircraft. A contact between an unbonded object and the system could produce a spark that could set off an explosion or fire. The authorizing commander for method 3 is the commander one level above the operating unit. This is the least desirable method since it does nothing to dissipate electrical charges (ground).

STATIC ELECTRICITY ON PERSONNEL AND CLOTHING

The human body conducts electricity. In a very dry atmosphere, a person can build and hold a charge of several thousand volts when walking over rugs or working in certain manufacturing operations.

Charge Formation

Outer clothing, especially if it is made of wool or synthetic fiber, builds a charge not only by absorbing part of the body charge but also by rubbing against the body or underwear. When the wearer takes the charged clothes off or moves them away from the body, the electrical tension or voltage increases to the danger point. If the clothes are wet with fuel, they may burst into flames when removed due to the dissipation of static electricity. Exposed nails on worn footwear can also cause sparks. This is a serious danger since fuel spills in refueling areas are common and fuel vapors near the ground ignite easily. Section III describes the correct clothing and footwear for fuel handlers.

Safety Measures

Before opening aircraft or vehicle fuel ports or doing any other operation that would let fuel vapors escape into the air, fuel handlers should bond themselves to the container by taking hold of it with a bare hand. If it is an aircraft or piece of metal equipment, they should take hold of a bare metal part with both hands for a few seconds. Although this type of bonding will not completely discharge static electricity, it will equalize the charge of the body with the charge on the equipment. Do not remove any piece of clothing within 50 feet of a refueling operation or in an area where a flammable vapor-air mixture may exist. Do not enter a flammable atmosphere after removing a garment. Wait at least 10 minutes before carrying the garment into such an atmosphere. If a fuel handler gets fuel on his clothes, he should leave the refueling areas as soon as refueling is completed. He should then wet the clothes with water before taking them off. If there is not enough water at the site to wet the clothes thoroughly, he should ground himself to a piece of grounded equipment by taking hold of it before taking off the clothes. A skin irritation from fuel is not fatal; the fire that may follow a static discharge from clothes can be fatal.

SPARKS IN AIRCRAFT FUEL TANKS

Be very careful when first filling a recently repaired aircraft fuel tank or the tank on a new aircraft. When fuel enters an empty tank, the fuel/air mixture in the tank passes through its explosive limits. Also, the flowing fuel creates large amounts of static electricity that may ignite the mixture. When filling the tank under these conditions, make sure the aircraft and refueling equipment are properly bonded and grounded. Pump fuel slowly into the tank. Also, have the maintenance team fill the fuel tank with nitrogen gas to displace oxygen in the tank. If the tank is filled with nitrogen, fuel may be pumped at a normal rate.

TANK VEHICLE OPERATIONS SAFETY

A discussion of specific considerations for tank vehicle operations follows. Refer to the section on aviation refueling for considerations related to aircraft refueling.

- Position a tanker in the transfer area so it is headed toward the nearest exit and away from buildings or other obstructions. Do not let other vehicles block exit routes.

- When possible, conduct petroleum operations on level ground. Always stop the engine, and set the brakes. Always chock the vehicle wheels when it is stopped. To chock the wheels, place an approved chock block between the front and rear tandem tires of the rear axle. Chock the tractor and trailer of tractor-trailer combinations.

- Space tankers a minimum of 25 feet during transfer operations and when parked. To avoid congestion during transfer operations and to provide greater safety margins, it is more desirable to maintain a spacing of at least 100 feet. Make sure a clear escape route exists in designated tanker parking areas. Be aware that empty tankers are at least, if not more, as dangerous as full tankers due to residual vapors.

- During all loading, unloading, and fuel-servicing operations, keep tractors coupled to tank semitrailers. However, if the semitrailer is designated and appropriately administered as a temporary storage tank, the tractor can be disconnected.

- Make sure the manhole cover stays open during all loading, unloading, and fuel-servicing operations. This prevents tank collapse in the case of tank vent failure. When opening the manhole cover, stand upwind of the cover to avoid inhaling petroleum vapors.

- Ensure the receiving vehicle's driver operates the dispensing nozzle. This will reduce the chance of spills, since the driver should be familiar with his vehicle and can safely fill it to the proper level.

- When the transfer operation is complete, ensure the fuel handler carries the discharge hose back to the tank vehicle. Avoid dragging it on the ground.

- Keep the canvas top and rear curtain of the tractor in place whenever the vehicle is carrying, loading, or unloading product. The top and curtain keep the tractor from being splashed with fuel from the vehicle catwalks.

- Check the pressure vacuum relief valves frequently in cold weather to be sure they are operating properly.

- Use tire chains on fuel tankers for traction on ice or in snow. Take them off on dry pavement to prevent their destruction.

TANK VEHICLE SAFETY

A discussion of specific safety steps to take when using tank vehicles for fueling operations follows.

- Post NO SMOKING signs around the area of operations, and enforce them. Prohibit smoking related materials around tank vehicles and in petroleum storage areas.

- Keep a fire extinguisher manned and ready for use. At permanent fueling installations, build a covered storage point near the fuel handling area for fire extinguishers and other fire extinguishing materials and equipment. Inspect fire extinguishers monthly for serviceability. Record the inspection date and the initials or name of the inspector on a tag. Attach the tag to the inspected extinguisher.

- Bond and ground all vehicles and equipment before any operation or while parked for long periods in designated parking areas. Facilitate bonding and grounding vehicles involved in a fuel transfer by touching the hose, drop tube, or discharge nozzle to the fill cap before removing it. Keep the nozzle in contact with the fill opening at all times during a transfer operation. When the operation is complete, close the fill cover before disconnecting bonding and grounding cables. Stop operations if there is an enemy attack, electrical storm, or fire in the area. Keep all possible sources of vapor ignition away during fuel transfer operations.

- Top load vehicles only during an emergency and when authorized by the commander. Top loading greatly increases the static electricity buildup and fuel vapors in the vehicle. It also increases the chances of a fuel spill. When top-loading, make sure the drop tube or discharge hose is close to the bottom of the tank. Pump fuel at a reduced rate until the end of the tube is covered; then switch to a normal rate. Have someone constantly observe the fuel level in the tank to prevent overfilling.

- Make sure all electrical equipment used around tankers is in good working condition and labeled as explosion-proof (if such equipment is available). Use explosion-proof extension lights, flashlights, and electric lanterns. Do not neglect normal safety procedures just because equipment is supposedly explosion-proof.

- Do not drag hoses across the rear decks of combat vehicles or near their exhaust systems. Armor plates and exhaust pipes become hot during operation and could damage hoses and cause a fire. Immediately stop fuel flow, and close the manhole cover if there is a tank compartment fire. Avoid driving near fires.

- Remove fuel-soaked clothes immediately. Before doing this, wet the clothes with water. If no water is available, temporarily ground yourself by holding a piece of grounded equipment with both hands. Then remove your hands from the grounded equipment, and take off your clothes.

Section II. Petroleum Fire Fighting

FIRE INSPECTIONS

The key to petroleum fire safety is an active prevention program. Conduct periodic fire inspections. Make sure all possible fire prevention precautions are in place and being followed. Ensure your inspection program covers your whole operations. Here are some key inspection points.

- Fire extinguishers. Make sure fire extinguishers are fully charged, properly placed, and clearly marked. They must also be protected, ready for use, and available in the number and type required.
- Fire water systems. Inspect for evidence of periodic testing of hydrants, standpipes and drains (when these items are present). They must be protected against freezing and physical damage.
- Fire hoses and couplings. Inspect fire hoses and to make sure they meet availability, quantity, and pressure requirements. Also, ensure they can be used with the existing water system and any other equipment that might be needed for a large fire.
- Check all equipment, grounds, bonds, and cathodic protection devices. Correct any conditions that may be a source of ignition. If they cannot be corrected immediately, report it.
- Check dikes around storage tanks for serviceability and adequacy. Ensure dike drains are closed except during supervised draining.
- Inspect pumps for leaks and spills. Ensure leaks and spills are cleaned up and reported immediately. Inspect pump houses, if present, for proper housekeeping and proper ventilation.
- Inspect permanent tank farms to see that dry grass and weeds have been cut. Ensure the cuttings are removed from dikes and tank areas.
- Check areas near where open flames for possible sources of flammable vapor release. Ensure NO SMOKING signs are posted in such locations to ensure that there is no smoking within 100 feet of fuel operations.
- Automatic opening and closing fire doors and windows (if present) must be kept in good operating condition and free from obstructions.
- Post and enforce rules covering those areas that permit hot work, such as cutting and welding.
- Mark pipelines, valves, and other equipment according to MIL-STD 101 or 161.

FIRE-FIGHTING PLAN

To fight and extinguish petroleum fires effectively requires A good plan. Every Class III supply point operation should have a fire prevention and firefighting plan. This plan may be very simple or complex. No matter what, it should cover in detail all possible fire problems. It should also cover firefighting resources, to include fire departments and engineer firefighting teams (where available). Soldiers and their supervisors at the Class III supply point have the primary responsibility for controlling and extinguishing fires. However, they should immediately notify their chain of command and outside support agencies such as the fire department when a fire breaks out. Ensure your firefighting plan covers these areas.

Fire Extinguishers

The primary method for fighting petroleum fires at smaller Class III supply points is portable, carbon dioxide fire extinguishers. Place one at each pump, collapsible tank, receiving and issuing point, can and drum cleaning and filling area, and packaged product storage area. Place other extinguishers where soldiers can get to them and critical areas of the supply point quickly. Develop a supply point map showing extinguisher locations. Place a map at each checkpoint and at several locations in the area of operation. Identify and develop other ways to extinguish fires, such as water or sand. Water is particularly important for controlling and quenching larger fires. If no natural water sources exist, request water storage and distribution support in the supply point.

Personnel

Assign two people to each fire extinguisher in the supply point. Make sure all soldiers in the supply point know and practice procedures for using the fire extinguishers. Also form a fire fighting team that drills extensively on fire fighting techniques to quickly react to and extinguish larger fires. A five person team is appropriate for the unit level supply point.

Evacuation Routes

Setup evacuation routes for vehicles and personnel. If a fire breaks out, all vehicles must be quickly moved from the area. Personnel not involved in fighting the fire must also leave. Evacuation routes should be the most direct route out of the supply point. Show these routes on the maps with the fire extinguisher placement.

Fire Drills

Use fire drills to train personnel to react quickly to fires. Fire drills should be as realistic as possible. Evacuation routes should be used and fire extinguishers manned. Conduct a fire drill at least once a month or when there is personnel turnover.

Fire Investigation

Investigate all fires. Do this to gain knowledge that may help prevent future fires. It is very important to know how and why a fire started. Check for an unsafe working condition or an improper act done by a soldier.

CLASSES OF FIRES

Underwriters' Laboratories, Incorporated groups fires into Class A, B, and C. The National Fire Protection Association groups them into Class A, B, C, and D. The four classes are described below.

- Class A. These are fires in combustibles such as wood, brush, grass, and rubbish. Water is the best agent for putting out Class A fires.
- Class B. These are fires in flammable liquids such as gasoline and other fuels, solvents, lubricants, paints, and similar substances that leave no embers. A smothering or diluting agent puts out Class B fires best.
- Class C. These are fires involving live electrical equipment such as motors, switches, and transformers. A smothering agent puts out C fires best. The smothering agent must not be an electrical conductor.
- Class D. These are fires in combustible metals such as titanium, zirconium, sodium, and potassium. A smothering agent puts out Class D fires best.

PRINCIPLES OF EXTINGUISHING FIRES

Fires require three elements to keep burning. They are fuel, heat and oxygen. Eliminating or sufficiently controlling one or more of these elements will extinguish the fire. The procedures to control these elements are given below.

- Fuel control. Immediately shut off the fuel flow, if possible. If the fire is in a broken pipeline, plug the break if possible. Then stop the flow at the nearest valve, and use foam on the burning fuel pools. Do not use water and foam together. Water will destroy the foam's effectiveness and cause the fuel to spread. For burning gas, shut off the flow and then put out the flame. Depending on the rate of flow of fuel into the fire, the danger of escaping gas, and a possible explosion, could be as great as the danger of combustion. When the danger of escaping gas is greater, it may be better to direct initial efforts at extinguishing the blaze, then cutting off the fuel flow.
- Heat control. Heat is transmitted by radiation, conduction, and convection. Heat radiates in all directions, and it is a hazard to storage tanks near a blaze. Heat is conducted through a solid or liquid substance. Convection takes place as heated air rises from the fire and circulates. This transfers heat to all combustibles in the area. Water in streams, spray, or fog is the best way to reduce heat and vapor. However, only trained people should use this method. Inexperienced people might cause the fire to spread when using water to extinguish it. Usually, the best way to protect a storage tank near a fire is to cool it with water.

• Air control. It is impossible to remove all air in the area of a fire. However, fire fighters can dilute the air, smother the fire, or both. Diluting the air means reducing the percentage of oxygen in the air to the point it can no longer support combustion. To smother the fire, use foam or similar agents to cut off all air at the combustion surface.

• Diluting air. Dilute air by using carbon dioxide, water fog, mist, or steam. The diluting action does not take place all at once. Continue diluting until the fire goes out. Carbon dioxide is a dry, noncorrosive gas that does not react chemically when it comes in contact with most substances. It does not conduct electricity. It is not a health hazard except in great concentration. Water fog dilutes the air and also helps protect personnel because it screens heat and washes fumes and smoke from the air. Live steam also does a good job of diluting. However, it also increases the heat in the area of the fire. Steam does a better job of diluting when applied to the top of a storage tank.

• Smother. Foam is one of the best ways to blanket and smother a petroleum fire. To do this, spread a tight covering of foam on the burning surface to cut off all air. Foam spreads easily on the top of a burning tank. Foam tends to break down in a fire. Continue to apply foam long and fast enough to let the tank cool below the fuel ignition temperature. The depth of foam needed can vary from a few inches for a small tank to several feet for a large tank. The foam source should furnish enough foam to put out a fire in the largest, protected single area rather than several small fires at one time. Fuel handlers can also smother small fires with sand, wet burlap, or a blanket.

• Air agitation. Those fighting fires in fixed storage tanks can use air agitation to help control or possibly put out fires. This method is not designed, nor is it recommended, to replace other methods of fighting or controlling fires. However, it can supplement other methods. It also can be used to fight fires when no other methods are readily available. The method involves pumping compressed air into the bottom of a burning tank to cause turbulence in the fuel stored in the tank. This lifts and mixes cool product with the hot product near the tank top. This cooling effect helps reduce vapors from the hot fuel. Any bottom water present in the tank is also mixed with the fuel in the tank. This helps quench the fire. This method works best with high flash point products (diesel fuels, fuel oils, kerosenes).

FIRE EXTINGUISHER TYPES

Trained personnel may use solid water streams, water sprays, and water fogs to control or extinguish fires in specific situations. However, the primary fire fighting tool is usually fire extinguishers. The Army uses both portable hand extinguishers and wheeled units. Portable hand fire extinguishers are effective only in a fire's earliest stages. They are called first-aid appliances. Portable hand fire extinguishers, except pump-tank units, are available in different sizes and types, The pump-tank unit uses water or an antifreeze solution (usually calcium chloride with corrosion inhibitors). Wheeled fire extinguishers offer more flexibility because they have longer hoses and greater capacities. Locate fire extinguishers (or signs indicating the closest one) throughout the supply point. The extinguishers must be in working order. Table 2-7 gives the rules for use and upkeep of fire extinguishers. Table 2-8, page 2-17, gives the types of portable fire extinguishers.

Table 2-7. Use and upkeep of fire extinguishers.

Know HOW to operate the fire extinguisher
Know WHICH extinguisher to use for each type of fire.
CHECK monthly to make sure extinguishers are in place
INSPECT monthly to see if extinguishers have been damaged
RECHARGE extinguishers immediately after use.
Have trained personnel EXAMINE extinguishers at least twice a year to make sure they are in good working condition. The inspection date and initials or name of the inspector must be recorded on a
TEST all pressure extinguishers hydrostaticallyy every 5 to 12 years (this depends on the extinguishers).
FOLLOW MANUFACTURER'S INSTRUCTIONS exactly for charging, maintaining, and using the extinguisher. Use TM 5-315 as a guide.

Table 2-8. Portable fire extinguisher types.

TYPE	AGENT	EFFECT	USE	EXPELLANT	ELECTRICAL CONDUCTOR	SUBJECT TO FREEZING
Soda-acid	Water	Cooling and quenching	Class A	CO2 gas from chemical reaction	Yes	Yes
Antifreeze	Calcium chloride	Cooling and quenching	Class A	Stored pressure, cartridge, or chemicals	Yes	No
Loaded stream	Alkali-metal salts	Cooling, quenching and retarding.	Class A Class B	Cartridge or chemicals	Yes	No
Carbon dioxide	Gas and dry ice	Diluting or smothering	Class B Class C	Self-contained pressure	No	No
Dry chemical	Treated sodium bicarbonate	Smothering	Class B Class C	Gas or cartridge	No	No
BCF	Bromochlorodi-flurομethane	Interference with chemical chain reaction of fire	Class A Class B Class C	Self-contained pressure	No	No
Purple K	Potassium bi-carbonate	Smothering	Class B Class C	CO2 gas	No	No

• Soda-acid. The soda-acid extinguisher is the most common water-solution extinguisher type that uses gas pressure as the expellant. The chemicals in the extinguisher are sodium bicarbonate (baking soda) and sulfuric acid. The sodium bicarbonate is in water-solution form in the extinguisher, and the acid is contained in a loosely stoppered glass bottle. When someone inverts the extinguisher, a chemical reaction produces carbon dioxide that builds up pressure and expels the water. Use this extinguisher type for Class A fires only.

• Antifreeze. The antifreeze extinguisher contains a calcium chloride solution charge. The expellant is gas from carbon dioxide cartridges or from a chemical reaction. The operator charges the extinguisher by inverting it and bumping it on the floor or by squeezing a valve lever. Use this type of extinguisher for Class A fires.

• Loaded-stream. The loaded stream extinguisher is charged with an alkali-metal salt solution and other salts. Potassium salts are part of the charge. The way the agent works on a fire differs with the class of the fire. It puts out Class A fires immediately and helps keep them from starting again. The way it works on small Class B fires is unclear. The agent produces no smothering vapor, but there seems to be a chemical reaction that tends to hold down combustion.

• Carbon dioxide. The carbon dioxide (CO_2) extinguisher comes in many sizes. The charge of liquid carbon dioxide under 800 to 900-PSI pressure is released by a hand valve at the top of the unit. A tube runs from the top to the bottom of the unit. This tube allows the release of only liquid carbon dioxide until the extinguisher uses about 80 percent of its charge. Gaseous carbon dioxide then flows until the charge exhausts. The charge flows in a high-velocity stream, and a horn or flaring nozzle keeps it from being diluted. When the operator releases the charge and it enters the horn, the chilling effect turns about 30 percent of the charge into dry ice or snow. Cooling of the gas as it expands causes this. Carbon dioxide dilutes air in Class B fires. It works well on Class C fires because it is not a conductor.

• Dry chemical. The dry chemical extinguisher is available in a wide range of sizes. The chief agent is sodium bicarbonate powder with additives that produce water repellency and free flow. The expellant is carbon dioxide, nitrogen, or compressed air. The extinguisher puts out the fire by smothering it. It works well on Class B and C fires.

• Halon 1211. Halon contains fluorocarbons that degrade the atmosphere's ozone layer. Because of this, a presidential directive has discontinued its use. Units should contact local environmental offices for disposition instructions for Halon and Halon fire extinguishers. Less harmful substances with similar fire extinguishing characteristics (such as FM-200) are replacing Halon.

• Purple K. The purple K extinguisher is a dry chemical extinguisher using the extinguishing agent potassium bicarbonate ($KHCO_3$), commonly called purple K. Carbon dioxide gas discharges the purple K in a wide stream from a low-velocity nozzle. This fire extinguisher works by smothering and is designed for use on Class B and C fires. Purple K is highly corrosive. Purple K extinguishers usually have a 20-pound capacity.

SECTION III. Aircraft Refueling Safety

BONDING AND GROUNDING DURING AIRCRAFT REFUELING

Bonding is the only static electricity control measure required for the aircraft itself during refueling. The refueling system must be grounded. Also, grounding at a separate grounding point and bonding are required for support equipment connected to the aircraft and for any other operations requiring electrical earthing.

AIR TRAFFIC CONTROL

Safe aircraft refueling requires some form of ATC. Each refueling point serving more than one aircraft requires an air traffic controller or some other adequately trained person for air traffic control. This person controls and directs refueling traffic and resupply aircraft. He provides flight personnel with information such as wind direction and velocity and remaining fuel supply. This information also includes enemy activity in the immediate area, landing hazards or obstructions, and emergency situations.

Required Skill

MOS 93H or pathfinder personnel have the required ATC skills. These soldiers are fully qualified to control military air traffic at either fixed or temporary airfields.

Required Equipment

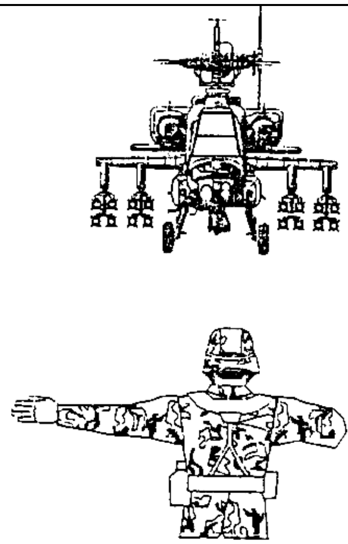
Fixed airfields have ATC communications equipment permanently installed. Large semipermanent or temporary refueling points use radio-equipped vehicles or temporary radio control towers for ATC. As a minimum, ATC requires an ATC-trained soldier with an FM radio capable of ground-to-air and ground-to-ground communication.

Provision of Service

Airborne and airmobile organization TOEs authorize air traffic control and pathfinder personnel. If an aviation unit sets up and operates a refueling point, it provides air traffic controllers or pathfinders. If a CSS unit establishes the point, either the supported aviation unit or the command tasking the unit to establish the refuel point provides the necessary ATC point.

AIRCRAFT MARSHALING SIGNALS

A soldier on the ground is responsible for directing aircraft into position for refueling. The Army uses the directional signals in STANAG 3117 for this. Figure 2-1, pages 19, 20, and 21 gives these standard signals.



Position of ground guide for a rotary-wing aircraft.

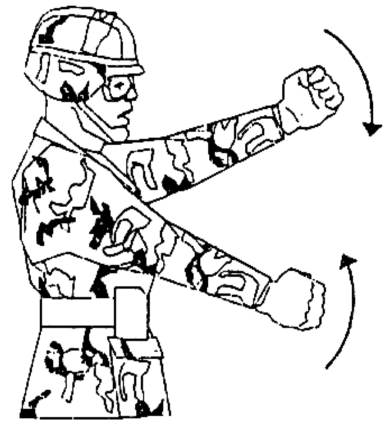
Proceed to next ground guide. Indicates direction of next ground guide.

Assume Guidance. Arms above head in vertical position with palms facing inward.

Move ahead. Arms a little apart with palms facing backward and repeatedly moved upward and backward from shoulder height.

Figure 2-1. Aircraft marshaling signals

Cut engine(s) or stop rotor(s). Either arm and hand level with shoulder with palm down**;** draw the extended hand across neck in a “throat cutting” motion**.**



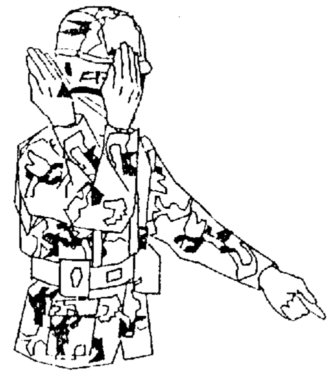
Hook up load. Rope climbing motion with hands.

Release load. Left arm forward horizontally with fists clenched; extended right hand making horizontal slicing motion below left arm with palm down.

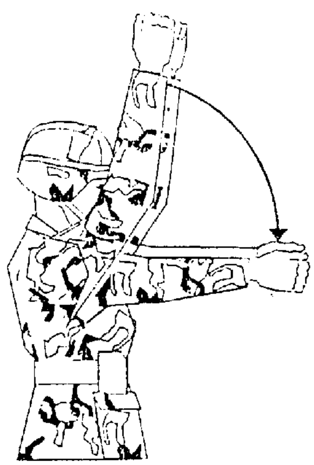
Load has not been released. Bend horizontally across chest with fist clenched and palm turned **down;** open right hand pointed up vertically to center of left fist.

Figure 2-1. Aircraft marshaling signals (continued)

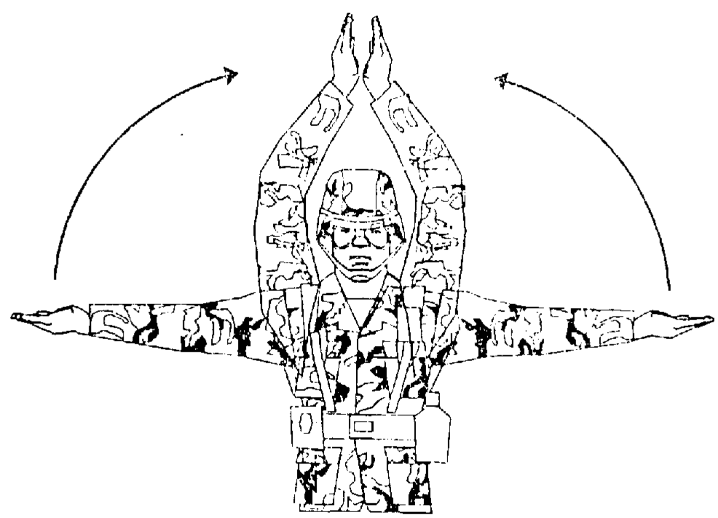
Turn to the left. Position right arm down, and point to left wheel or skid; move left arm repeatedly upward and backward.



Turn to right. Position left arm down, and point to right wheel or skid; move right arm repeatedly upward and backward.



Landing direction. Ground guide starts with arms raised vericaly above head and facing toward the point where the aircraft is to land. The arms are raised repeatedly from a vertical to a horizontal position, stopping in a horizontal position. □



Moving upward. Extend arms horizontally to the side, beckoning upward with palms turned up.

Figure 2-1. Aircraft marshaling signals (continued)

LANDING AIDS

Semipermanent refueling points and forward area refueling points require landing aids. Landing aids are given below.

• Semipermanent Refueling Points. Semipermanent refueling points require lighted and marked airfields and landing pads. Use the information below to light and mark the semipermanent refueling point.

• •Lighting. Units operating large semipermanent airfields, heliports, and refueling points must properly light them for night operation. Engineers can guide them on the appropriate airfield light set and power source for long-term use. The emergency runway marker light set (LIN L64131, NSN 6230-00-542-6680) should be used for temporary lighting. This set includes 12 beanbag lights in a carrying case. Batteries (NSN 6135-00-050-3280) are requisitioned separately. Settings on the light allow it to give off a steady beam, either vertical or horizontal, or flash. Each has a clear lens and five colored lenses (amber, blue, green, red, and opaque). The set comes with two spare bulbs for each light (NSN 6240-00-761-0979) and with four tent pins per light to anchor the light to the ground. The lights, because of their flexible, weighted beanbag bases, can be used to mark obstructions such as stumps, rocks, and trees. The lights are not explosion proof. For night operations, units operating the refuel point should clearly define landing areas with lights to ensure adequate spacing between refueling aircraft.

• •Markings. Large semipermanent airfields and refueling points may have cement or asphalt landing pads. Mark paved pads with reflective tape. Number regular landing pads, and letter pads at refueling nozzles. If the landing pads are not paved, mark them (number or letter as appropriate) with reflective paint. Reflective paint works well on most surfaces. Also, use reflective paint to mark existing aircraft hazards that cannot be marked with reflective tape. Use AR 385-30 for guidance on marking landing and refueling areas on the field. Using PSP or other similar types of marking or surfacing panels is not recommended. Even when such items are well anchored with pegs, the rotor wash from helicopters can pull them free and draw them up into the rotors. In addition, their use is not desirable in an area of potential fuel spills. Fuel soaks into the ground under the PSP and vaporizes slowly, creating both fire and health hazards.

• Forward Area Refueling Points. Properly lighting and marking forward refueling area refueling points is very important. You must make lighting and marking visible to pilots while concealing them from threat forces. If threat forces discover refueling operations, they will try to disrupt those operations. Threat forces can destroy refueling operations. They will use aircraft, maneuver forces, special operations teams, sabotage and reconnaissance units, and nets of direct action and support agents. All personnel should be aware of the tactical situation. They must have current information on the opposing forces so they can effectively plan refueling point security.

• •Lighting. In a forward area, usually you light landing zones only when US or friendly forces have air superiority. If night lighting is required, use the beanbag light set. The inverted Y is the recommended system for approach cues. Use at least two lights to mark the touchdown point. All lights should be hooded or turned upside down for security until the last practical moment when helicopters are inbound. Figure 2-2 shows the layout of the inverted Y.

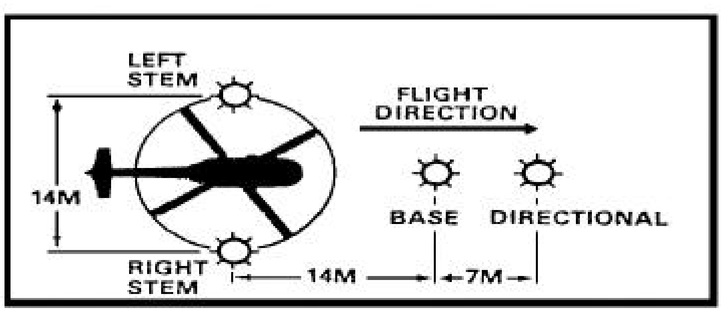


Figure 2-2. Inverted Y

• •Markings. Refueling points in forward areas must be camouflaged. Pilots locate such points by tactical coordinates and by using guidance from the air traffic controller. In a nontactical area, use reflective paint to mark the refueling point.

DANGERS FROM AIRCRAFT

Fire is the greatest danger to personnel in refueling operations. Other dangers to personnel working around aircraft come from rotor blades, propellers, rotor and prop wash, jet engine exhaust, and live armaments. These dangers and appropriate safety measures are given below.

Rotor Blades

The most serious danger is that of being struck by the main rotor blades during rapid refueling or by the main or tail rotor blades on approaching or leaving the aircraft. Remember that the ends of the main rotor blades droop when the engine is idling, so there is less clearance at the ends of the blades than at the rotor hub. People approaching the helicopter should keep their head down when approaching a helicopter. Be especially careful if there is a rise in the ground or anything lying on the ground. Go around, not over, such obstructions. Approach the helicopter from the side, never from the rear. (The tip of the tail rotor may be as low as 1 1/2 feet off the ground, and the pilot cannot see the tail of his helicopter.) To move from one side of a helicopter to the other, always go around the front, never around the rear.

Propeller

Do not touch the propeller of an aircraft. If the aircraft engine is still warm, moving the propeller could make the engine turn over and start.

Rotor and Prop Wash

The danger in rotor and prop wash is flying debris. The rotor wash creates a doughnut-shaped pattern-a-rush of wind that blows downward under the blades and then curves up and over to suck objects into the rotor hub. Even small objects, such as a flight cap with wings pinned on it, can be sucked into the rotor hub with such force that rotor blades can shear off the wings and cause them to become dangerous projectiles. Keep the refueling area free of trash and debris that could injure personnel or damage aircraft if sucked up or blown out by rotor or prop wash. Wear the clothing specified in this chapter. Do not wear anything loose that could be sucked off by the rotor wash. Keep shirt sleeves rolled down and buttoned to protect arms. Beware of the area behind propellers where even light objects can become projectiles.

Jet Engine Exhaust

The danger in jet exhaust is its high heat which can cause burns. Stay away from the exhaust and exhaust vents. Remember the temperature of an idling turbine engine is between 470° and 500°F.

Live Armament

Live armaments may accidentally fire during refueling operations. Check with the copilot of the aircraft to make sure all armaments are on SAFE before approaching the aircraft. Aviation unit commanders must develop and enforce SOPs designed to provide for maximum safety from armaments during ground operations.

SWITCH FUELING AIRCRAFT

Switch fueling is fueling an aircraft with a fuel of flammability characteristics different from those of the fuel already in the tank. The flammability characteristics of the mixed fuel will be different from the two fuels involved. The danger is that, if a spark should occur in the tank, the vapor-air mixture above the fuel may be in the flammable range and an explosion could result. The electrostatic potential that could cause such a spark exists inside the tank on the fuel's surface. This static danger cannot be removed by bonding the nozzle to the fill port. Because bonding the nozzle to the aircraft does not protect against a spark on the fuel surface in the tank, take other protective measures when switch fueling. One protective measure is to use an antistatic additive. If the alternative or emergency fuel contains the required concentration of antistatic additive, the additive will not ignite by an electrostatic spark. However, many commercial fuel suppliers are not equipped to inject the additive. If an antistatic additive cannot be used, the nozzle flow rate should not exceed 50 percent of rated flow. Cutting the flow in half helps two ways. It allows more time for the static charge on the fuel surface to dissipate. It also reduces splashing and misting inside the tank as the fuel is added. Aircraft commanders know the civilian aviation industry uses only Jet A or A1 kerosene grade jet fuels. Refueling aircraft containing JP-4 with these fuels constitutes switch fueling. Changing to JP-4 after using a kerosene-grade fuel also constitutes switch fueling (JP-8 is a kerosene-grade fuel). Only use alternative or emergency fuels as prescribed in TB 55-9150-200-24.

DANGERS FROM FUELS

The main day-to-day dangers from fuel, outside of fire, are its effects on the human body. Lead is a deadly poison that accumulates in the body, especially in the liver. It can cause nerve damage and death. The body easily absorbs lead through the skin. It can also absorb lead through the lungs by breathing vapors of leaded fuels like AVGAS. Another danger from fuel is skin irritation. Aviation fuels take the natural fats and oils out of skin. The fuel leaves skin rough, dry, chapped, and cracked. Infections start easily in dry skin cracks. JP-4, especially if it stays on the skin any length of time, can cause blisters. Fuel is both painful and dangerous if it gets in the eyes, nasal passages, or mouth. It can be fatal if swallowed. You can prevent and treat these problems as given below.

- Prevention. The best way to control skin irritation from aviation fuels is to avoid contact with them. There are two ways of doing this. First, wear the clothing specified in this chapter. Second, handle the fuels carefully. In open-port refueling, the danger comes from overfilling the tanks or losing control of the open nozzle in a power surge caused by closing another nozzle in the system. When the tank is almost full, slow the rate of flow from the nozzle. Watch the tank carefully so as not to overfill it. To keep from losing control of the nozzle in a power surge, hold the nozzle firmly and keep it pushed in as far as it will go into the aircraft port.

- First Aid. If AVGAS or jet propulsion fuel comes in contact with skin, wash it off immediately with soap and water. In forward areas with limited water supplies, use canteen water to wash off the fuel. If aviation fuel gets in the eyes or mouth, flush them thoroughly and repeatedly with water. Do not swallow the water. Do not induce vomiting. Get medical help as quickly as possible. If possible, establish a permanent eyewash at a refueling site. If aviation fuel gets on clothes, remove them promptly and carefully by following the procedures in this chapter. These procedures protect the soldier from the danger of a static spark igniting his clothes as he removes them. MSDS's give first aid procedures for exposure to hazardous materials.

PROTECTIVE CLOTHING

Personnel must wear protective clothing when handling fuels. It is the command's responsibility to ensure that all protective clothing required by the MSDS is provided to the aviation fuel handler. Clothing includes field wear, goggles, hearing protection, gloves, and boots. Each is discussed in Table 2-9, page 2-26.

WEAR OF CLOTHING AND PERSONAL ITEMS

Wear shirt sleeves rolled down and buttoned. Do not wear or carry loose items of clothing. Do not wear the wool sweater when refueling as the material produces static electricity. Do not carry anything in shirt pockets because items may fall out of them and cause sparks or fall into the fuel tank. Do not wear jewelry that might spark against metal surfaces. Ensure footwear is not damaged. Exposed nails can cause sparks.

MISSION-ORIENTED PROTECTIVE POSTURE GEAR

MOPP gear restricts movement and activities. Also, it makes it difficult to perform even the simplest tasks. Wear MOPP gear only when threat forces have used NBC weapons or are likely to do so. MOPP gear should be worn during NBC training exercises.

SIGNS

Five signs are used as warning or other notices in aircraft refueling operations. These signs and their restrictions are given below.

- No Smoking. Post NO SMOKING signs 50 feet from the refueling area to warn personnel that they cannot bring lighted smoking materials, lighters or matches into the area.

- Passenger Marshaling Area. If there is no terminal building, clearly mark a passenger marshaling area at least 50 feet from any refueling area and at least 50 feet from the fuel supply storage area. See that personnel, other than members of the aircraft crew, get off the plane and go to the terminal or passenger marshaling area before refueling starts. Passengers may not return to the aircraft until refueling is completed.

- Restricted Area. Post RESTRICTED AREA signs at semipermanent or temporary refueling point where vehicles, repair tools, or activities could pose a spark danger. Post RESTRICTED AREA signs to keep unauthorized personnel and vehicles at least 50 feet from any refueling area.

• Emergency Shutoff. Post EMERGENCY SHUTOFF signs at each cutoff point in any fixed or semipermanent refueling system that provides for emergency shutoff of the fuel system. The signs should include instructions so that anyone can shut off the system in an emergency.

• Alarm. Post ALARM signs at points from which an alarm can be given (for example, phones and sirens). The signs should include instructions, if needed, so that anyone can give the alarm in an emergency.

Table 2-9 Special clothing for aviation fuel handlers.

NOMENCLATURE	CTA/LIN	NSN	REMARKS
Uniform	50-900	See CTA	No special uniform specified. Do not wear wool sweater or other wool or nylon items (causes static electricity).
Helmet Assembly for Rearming Refueling Personnel	50-900/83482N	Must be assembled from following components:	
		Helmet cloth - 8415-00-861-3527 (size 6-3/4)	
		8415-00-071-8786 (size 7-1/4)	
		8415-00-071-8785 (size 7) 8415-00-071-8787 (size 7-1/2)	
		Pad back 8415-00-178-6830	
		Pad front 8415-00-178-6831	
		Shield back 8415-00-178-6855	
Uniform	50-900	See CTA	No special uniform specified. Do not wear wool sweater or other wool or nylon items (causes static electricity).
		Shield front 8415-00-178-7013 Headset, microphone 5965-01-204-8505 (for type AGU-24/P)	
		Aural protector 4240-00-759-3290 (for type HGU-25/P)	
Flyer helmet	50-900/K34252	See CTA	Alternate to above helmet. Contains earpieces, microphone, and visor.
Motorcyclist helmet	50-900/83491N	See CTA	Alternate to above two helmets. Require use of goggles and hearing protection as discussed below.
Goggles	50-900/J71304	See CTA	Wear motorcyclist goggles with motorcyclist helmet.
Plug, ear, hearing protection	8-100	See CTA	Hearing protection method to use with the motorcyclist helmet
Earmuffs (aural protector, sound)	50-970	4240-00-022-2946	Hearing protection method to use with the motorcyclist helmet.
Gloves	50-900/69434	8415-00-641-4601	Fuel-resistant gloves, use instead of leather gloves and aircrew fire-retardant gloves.
Boots	50-900/C08735	See CTA	These are fuel-resistant safety boots that should be worn in lieu of any

			other type of boot.

Section IV. Health Hazards

PETROLEUM HEALTH HAZARDS

All petroleum products present health hazards. Fuel handlers cannot eliminate these hazards. However, they should understand them. They should also know the measures to reduce them to a minimum. The right health protection measures will allow fuel handlers to work with petroleum products with no ill effects. FM 21-11 gives more information.

PETROLEUM HAZARD CLASSIFICATION

Petroleum health hazards are classified according to the type of petroleum contamination present. Petroleum contaminant classifications are dust, gas or vapor, or liquid. Contaminants are further classified by their effect on the body (their *physiological effect*). (Physiological effects affect the body's organ, tissue, and cell function.) Contaminant classifications by physiological effects are toxic, anesthetic, or irritant. Petroleum inhaled into the lungs, ingested into the digestive system, or touching the skin causes these effects. Any given petroleum product can be hazardous in more than one contaminant form. It can also produce a combination of physiological effects.

DUSTS

Dusts are solid particles of substances that result from mechanic. They come from operations such as grinding, scraping, buffing, riveting, rivet cutting, or drilling. Dusts also come from handling dust-producing materials (as in sanding or sand-blasting). Evaporation or burning of liquids and residues containing finely divided substances also cause dusts. Some dusts are hazardous because they are flammable. Dusts of all combustible substances ignite or explode under certain conditions. Consider makeup and physical properties, length of exposure, and quantity when evaluating dust hazards. There are three types of dusts: toxic, fibrosis-producing, and nuisance.

- Toxic. Toxic dusts injure body organs and tissues when inhaled into the lungs. If ingested into the digestive system, they attack the body through the liver. Certain toxic dusts also irritate the skin. Lead, manganese, mercury, arsenic, and their compounds make toxic dusts. Cleaning and repairing tanks that contained leaded gasoline produce one of the most toxic dusts fuel handlers will encounter. Lead dust and fumes also result from burning sludge from leaded gasoline. Lead's toxic effects build up in the body. However, the body can resist lead poisoning if it is given enough time between exposures. If it is not, each exposure adds to the effects of the one before it. Units should have their soldiers tested for lead periodically.

- Fibrosis-Producing. Fibrosis-producing dusts injure the lungs in such a way that normal tissue is replaced with fibrous or scar tissue. The most common example is dust containing silica. It causes the disease called silicosis. People who run grinding or polishing machines or sanding and sandblasting equipment may be exposed to such dusts.

- Nuisance. These dusts may not cause severe injury, but they may cause inflammation and respiratory ailments. Personal allergies may add to the effect of dusts.

GASES AND VAPOR

People often use the terms gas and vapor to mean the same thing. However, there is a difference. A gas exists solely as a gas at ordinary temperature and pressures. For example, oxygen is only present as a gas at the pressures and temperatures normally found on the earth. The only way to make it into a liquid or solid is to place it under extremely high or extremely low temperatures. This involves hundreds of degrees below those normally found. A vapor is the gas form of a substance that is also a solid or liquid at ordinary temperatures and pressures. Petroleum fuels are liquid at normal pressures and temperatures, but it gives off small quantities of gaseous petroleum (petroleum vapor) Gases and vapors are divided into four groups depending on their effects on the body: poisons (toxic), asphyxiants, anesthetics, or irritants. A gas or vapor can have multiple effects on the body. These effects are given below.

- Poisons. Poisonous or toxic gases and vapors have various effects on the body. They can injure or destroy organs, the blood forming system, tissues, or bones. The most poisonous gases or vapors are hydrogen sulfide (found in crude oils with high sulfur content) and tetraethyllead vapors (found in leaded gasoline). Fuel handlers should avoid concentrations of these potentially fatal vapors at all times. Other dangerous gases, listed in order of toxicity, are: sulfur dioxide, ammonia, methyl bromide, butane, propane, and the various forms of freon. (Freon is often used as a refrigerant.) The carbon dioxide in fire extinguishers is slightly toxic. Carbon tetrachloride, often used in various cleaning fluids and in some fire extinguishers, is toxic, and its effects build up in the body. It can also decompose into another highly toxic gas, phosgene. For these reasons, carbon tetrachloride is no longer approved for use in extinguishing fires. All vapors from flammable products are toxic to some degree.

• Asphyxiants. Simple asphyxiants are gases and vapors that keep the lungs from getting oxygen. In other words, they replace the oxygen that is in the air. Some asphyxiants are methane and its related hydrocarbons, hydrogen and acetylene (used in welding and torch-cutting). Another dangerous, commonly encountered asphyxiant is carbon monoxide. Carbon monoxide is produced by running engines and any type of fire. Carbon monoxide chemically reacts with blood in such a way that the blood is unable to absorb enough oxygen to sustain the organs of the body. Carbon monoxide is tasteless and odorless. Victims gradually become extremely sleepy, and eventually pass out without realizing what is happening to them. The key to defeating asphyxiants is proper ventilation of areas where they are present.

• Anesthetics. Anesthetic gases and vapors have a narcotic effect that depresses the central nervous system to the point where breathing failure occurs. All hydrocarbon vapors (which includes petroleum products) have this effect. The most narcotics are acetone, the ethers, benzene, naphthas, gasolines, and jet fuels. Other anesthetics are hydrocarbon derivatives that contain members of the chlorine family. Exposure to burning hydrocarbon vapors can cause tremors of the heart ventricles. The narcotic effects of gasoline and jet fuel increase with their aromatic content.

• Irritants. Irritant gases and vapors inflame the lungs and respiratory tract. They may cause pneumonia and other pulmonary diseases or make the victim more susceptible to them. Most flammable gases and vapors irritants whether they are poisonous, narcotic, or neither.

LIQUIDS

Flammable liquid products can cause internal medical problems if swallowed. Liquid petroleum is also easily absorbed through the skin, causing similar problems. These effects are given below.

• Inside the Body. Flammable liquid products are harmful if they contact the skin in the mouth and potentially fatal if someone swallows them. If someone gets petroleum in their eyes and mouth, flush their eyes and mouth thoroughly and repeatedly with water. They should get medical help at once.

• On the Skin. Flammable liquid petroleum also causes skin contamination. The seriousness of skin contamination depends on the substance. The most serious effects result from contact with strong acids, alkalis, and rocket fuels. Effects from gasoline, jet fuel, and solvents are less serious, but still very harmful. Fuels, solvents, paints, lacquers, and varnishes dry up natural fats and oils on the skin. This leaves the skin harsh, dry, and chapped. This condition is known as dermatitis. These unnatural skin openings or lesions increase the chances of infection. If a soldier gets petroleum on his skin, he should wash it off at once with soap and water. If a soldier soaks his clothes with fuel, he should wet them with water before taking them off. If no water is available, he should ground himself by taking hold of a grounded piece of equipment. This step prevents sparking from static electricity.

FUMES AND MISTS

People often use the term “fume” to mean the same thing as gas or vapor. Fumes are actually small particles in the air of solids that can turn directly from solids to vapors without becoming liquid first. This process is called sublimation. Dry ice, iodine, and sulfur are some of the commonly found substances that do this. Lead compounds found in paint and leaded gasolines also form fumes. Fumes differ from dusts in that dusts cannot return to their solid form.